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Predicting Co-Parenting Quality From Marital Adjustment, Parenting Self-Efficacy, and Psychological Distress Using Gradient Boosting Regression

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A B S T R A C T

Objective: This study aimed to predict co-parenting quality from marital adjustment, parenting self-efficacy, and psychological distress among Brazilian parents using Gradient Boosting Regression and to determine the relative predictive importance and nonlinear contribution of these variables.

Methods and Materials: This cross-sectional predictive study included 462 Brazilian parents who were married or cohabiting with the other biological or adoptive parent of at least one child aged 3–12 years. Co-parenting quality was assessed using the Coparenting Relationship Scale, marital adjustment using the Revised Dyadic Adjustment Scale, parenting self-efficacy using the efficacy component of the Parenting Sense of Competence Scale, and psychological distress using the Kessler Psychological Distress Scale. The dataset was divided into training (80%, n = 369) and holdout test (20%, n = 93) subsets. Gradient Boosting Regression was tuned using five-fold cross-validation. Predictive performance was evaluated using R^2, root mean squared error, mean absolute error, and mean absolute percentage error and was compared with multiple linear regression. Predictor importance was examined using permutation importance and SHAP values.

Findings: In the holdout sample, Gradient Boosting Regression explained 61% of the variance in co-parenting quality, with RMSE = 15.95, MAE = 12.41, and MAPE = 8.73%. The model outperformed multiple linear regression, which explained 49% of the variance and yielded RMSE = 18.23 and MAE = 14.52. Marital adjustment showed the greatest predictive importance, with normalized importance = .48, permutation importance = .264, and mean absolute SHAP value = 12.84. Psychological distress was the second most important predictor (.31; .171; 8.19), followed by parenting self-efficacy (.21; .108; 5.73). Partial-dependence patterns indicated positive nonlinear associations for marital adjustment and parenting self-efficacy and a negative nonlinear association for psychological distress.

Conclusion: Co-parenting quality was predicted with substantial accuracy from marital adjustment, psychological distress, and parenting self-efficacy, with Gradient Boosting Regression outperforming conventional linear modeling.

Keywords: *co-parenting quality; marital adjustment; parenting self-efficacy; psychological distress*

1. Introduction

Co-parenting refers to the ways in which parents coordinate, support, negotiate, and share responsibilities related to raising their children, and it constitutes a family-level process that is conceptually distinct from both the marital relationship and individual parenting behavior. Effective co-parenting is characterized by mutual support, agreement regarding child-rearing goals, appropriate division of parenting responsibilities, constructive management of disagreements, and protection of children from destructive interparental conflict. Although co-parenting develops within the broader family system, its quality may influence the emotional climate in which children are raised and may consequently affect parental well-being, parenting practices, and child adjustment. Contemporary family research increasingly views the family as an interconnected system in which individual psychological resources, couple functioning, and parenting processes mutually influence one another. Evidence that family relationship quality is associated with psychological and cognitive well-being among caregivers further illustrates the importance of understanding relational processes beyond isolated parent characteristics (Jang et al., 2024). Similarly, studies of family adaptation during major stressors have shown that family-level relational resources can protect both parents and children from adverse outcomes (Partington et al., 2022). Consequently, identifying the factors that distinguish strong from impaired co-parenting relationships represents an important objective for family psychology.

The marital relationship represents one of the most immediate interpersonal contexts in which co-parenting develops. Although marital functioning and co-parenting are theoretically distinguishable, emotional experiences within the couple relationship can spill over into the parental subsystem. Spouses who communicate effectively, resolve conflicts constructively, express affection, and maintain relational cohesion are generally better positioned to coordinate their parenting behaviors. Marital adjustment therefore reflects not merely satisfaction with the intimate partnership but also the couple's capacity to negotiate differences and preserve functional collaboration under everyday family demands. Psychometric research on marital satisfaction among parents has reinforced the relevance of evaluating couple functioning in populations facing different levels of family risk (Nunes et al., 2022). Couple-based research has also demonstrated that marital and co-parenting processes can be addressed simultaneously in family intervention because difficulties in one domain may become embedded in the other (Darwiche et al., 2022). These observations support the proposition that marital adjustment may be among the strongest predictors of perceived co-parenting quality.

The association between marital functioning and parenting appears particularly salient under circumstances of elevated caregiving demands. Research involving mothers of children with autism spectrum disorder has demonstrated meaningful connections between resilience and marital adjustment, suggesting that the quality of the couple relationship forms part of the broader adaptation process when parenting demands are substantial (Güçlü & Hürmeydan, 2024). Among parents of children with autism, psychological flexibility and psychological capital have likewise been associated with marital quality, indicating that individual psychological resources and couple functioning operate within an interconnected family context (Bayazy & Gur, 2024). Affiliate stigma has additionally been associated with marital satisfaction among parents of children with intellectual disabilities, emphasizing that contextual stress can penetrate the couple relationship and potentially alter family collaboration (Molero et al., 2024). A broader family perspective is therefore necessary because co-parenting is likely to emerge from interactions among couple quality, parenting resources, stress exposure, and psychological adaptation rather than from a single isolated factor.

Theoretical perspectives on family systems and spillover processes provide a useful explanation for why marital adjustment may predict co-parenting quality. Constructive marital interactions may create emotional security, reciprocal trust, and communication patterns that facilitate parenting coordination. In contrast, unresolved marital conflict may diminish cooperation and increase defensive or hostile behavior in parenting-related exchanges. Evidence from fathers has shown that marital conflict is related to parenting stress and parenting efficacy and may influence positive parenting patterns, illustrating how couple-level difficulties can extend into the parenting subsystem (Kim, 2026). Research on marital satisfaction and parenting-related self-efficacy has similarly indicated that the quality of intimate relationships can be associated with parents' confidence in performing important caregiving functions (Maleki & Youseflu, 2023). These findings suggest that marital adjustment may influence co-parenting through both relational and individual psychological pathways, making it

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an especially important predictor in multivariable models of family functioning.

Parenting self-efficacy constitutes another important psychological resource that may contribute to co-parenting quality. Parenting self-efficacy refers to parents' beliefs regarding their capacity to manage child-rearing demands effectively, influence their children's development positively, and perform parenting tasks competently. Parents with stronger efficacy beliefs may be more likely to approach parenting challenges proactively, communicate their needs clearly, and participate confidently in shared parenting decisions. In contrast, parents who doubt their own parenting competence may become more dependent on, defensive toward, or critical of their partners during co-parenting interactions. Research examining parental self-efficacy across the life course demonstrates that perceived competence remains psychologically meaningful even among older adults with continuing parenting responsibilities (Kestler-Peleg et al., 2023). Furthermore, perceived parental competence has been associated with adaptation in highly stressful circumstances such as bereavement, indicating that confidence in one's parenting role may remain protective when family structures and emotional resources are disrupted (Williams, 2023).

Evidence from parents exposed to significant caregiving stress further supports the importance of self-efficacy. Among parents raising children with autism spectrum disorder, self-efficacy has been identified alongside coping, social support, and positive perceptions as an important component of parental adaptation (Higgins et al., 2022). In parents living with cancer, psychological distress, parenting concerns, self-efficacy, and emotion regulation have been shown to coexist as interconnected aspects of parenting under substantial pressure (Strandh et al., 2024). Parental characteristics may also interact with child-related factors in shaping parenting behavior, as demonstrated by evidence linking paternal autism traits with patterns of parenting (Sakakihara et al., 2024). These findings imply that parental confidence is not merely an isolated cognition but may function as a resource affecting how parents regulate themselves, interpret parenting challenges, and negotiate cooperation with their partners.

Parenting self-efficacy may be particularly important because co-parenting requires parents not only to perform individual caregiving behaviors but also to coordinate those behaviors with another adult. When both parents perceive themselves as competent, parenting disagreements may be easier to approach as solvable differences rather than threats to personal adequacy. Conversely, low parenting self-efficacy may intensify sensitivity to criticism and increase reliance on maladaptive patterns such as withdrawal, competition, or gatekeeping. Research integrating individual and couple psychological characteristics has demonstrated that parenting-related psychological variables can contribute to relational and marital satisfaction (Chiș et al., 2022). Likewise, parent competence and psychological distress have been linked to child psycho-behavioral adaptation, emphasizing that parental confidence and psychological functioning operate within reciprocal family processes (Li et al., 2023). These findings justify including parenting self-efficacy alongside marital adjustment when predicting co-parenting quality.

Psychological distress represents a third major factor that may undermine effective co-parenting. Psychological distress is a broad construct encompassing symptoms such as anxiety, depressive affect, emotional tension, and reduced psychological functioning. Distress can diminish patience, emotional availability, executive control, and the capacity for constructive interpersonal problem solving. During the COVID-19 pandemic, elevated parental stress, anxiety, and depression were widely observed among parents exposed to physical distancing and related disruptions (Johnson et al., 2021). Other research has demonstrated that coping strategies and social support can modify psychological distress among mothers during periods of heightened environmental stress (Lubis et al., 2024). Family resilience research conducted during the pandemic similarly identified risk and protective processes that contributed to families' ability to withstand severe stressors (Cıhan & Var, 2022). Collectively, these findings indicate that psychological distress should be treated as a central family-functioning variable rather than solely as an individual mental health outcome.

Distress may impair co-parenting because parents experiencing emotional overload have fewer resources available for monitoring their own reactions and responding sensitively to their partners. Persistent worry, sadness, irritability, or exhaustion may reduce collaborative problem solving while increasing negative attribution, conflict escalation, or emotional disengagement. Research directly examining parenting stress, general distress, and co-parenting quality has provided evidence that distress within one parent may have both actor and partner implications for the co-parenting relationship (Turgeon et al., 2023). Mental health difficulties can also interfere with broader family functioning, as observed among veterans experiencing

postdeployment mental health concerns (Zelkowitz et al., 2023). Psychological adjustment following relationship separation has likewise been linked to intrapersonal psychological differentiation, reinforcing the wider significance of emotional regulation and psychological functioning in family transitions (Moral et al., 2021). These findings support the expectation that greater psychological distress will correspond to poorer co-parenting quality.

Psychological distress is especially relevant during periods surrounding childbirth and early parenting, when both individual and relational demands often intensify. Longitudinal research in Iran has demonstrated associations between paternal postpartum depression and psychosocial variables, highlighting that fathers' mental health warrants attention within the postnatal family system (Shariat et al., 2022). More recent couple-focused research has examined postpartum depressive symptoms in relation to perfectionism and anxiety, illustrating the complexity of psychological distress within parental couples (Latulippe et al., 2026). Although postpartum distress may initially be experienced by one parent, its consequences can become relational because parenting responsibilities require extensive coordination, emotional reciprocity, and adjustment to changing family roles. Thus, distress is theoretically positioned to interfere with the cooperative processes required for effective co-parenting.

The effects of distress may become particularly visible in families exposed to illness or chronic caregiving demands. Research among parents of autistic children has identified associations among parental distress, marital satisfaction, and children's functional impairments, demonstrating how individual mental health, couple functioning, and child-related demands may become intertwined (Özoğuz et al., 2025). Among families coping with cancer, the relationship context has similarly been shown to influence parenting concerns when one parent has advanced cancer (Milbury et al., 2024). Work-family conflict may further contribute to parental mental health difficulties and children's emotional and behavioral problems, highlighting the spillover of stress from occupational contexts into family relationships (Dias et al., 2026). These findings reinforce the view that psychological distress may function as a proximal indicator of the cumulative pressures experienced within the broader family system.

The ability of parents to adapt to stressful circumstances also depends on the availability and accumulation of psychosocial resources. The Double ABC-X framework conceptualizes family adaptation as the outcome of interactions among stressor accumulation, available resources, perceptions, coping, and subsequent adaptation. Contemporary applications of this model have demonstrated the importance of multiple interacting resources in understanding parental adjustment (Brik & Wang, 2025). A similar resource perspective can explain why marital adjustment and parenting self-efficacy may protect co-parenting quality while psychological distress compromises it. Supportive couple functioning can provide interpersonal resources, parenting self-efficacy can provide intrapersonal mastery, and lower psychological distress can preserve emotional and cognitive resources required for cooperation. Research showing that psychosocial intervention can reduce distress among caregivers of children with intellectual disabilities further illustrates that parental psychological functioning is modifiable rather than fixed (Masulani-Mwale et al., 2022).

Resource-based processes have also been identified in families facing serious illness. Among mothers with breast cancer, gains in psychological and relational resources have been associated with reductions in harsh and inconsistent parenting through serial psychological pathways (Zamir et al., 2022). Research involving gynecological cancer patients has likewise highlighted the importance of self-disclosure and perceived partner responsiveness for parenting-related concerns, suggesting that responsive intimate relationships can influence how parents experience their parenting responsibilities (Ding et al., 2026). These findings indicate that effective co-parenting is likely to reflect an accumulation of supportive relational and psychological processes rather than a single linear determinant. In this regard, marital adjustment, self-efficacy, and distress represent conceptually distinct but mutually relevant resources and risks.

Another reason to examine these predictors simultaneously concerns their potential nonlinear and interactive effects. A moderate increase in marital adjustment may produce relatively little change in co-parenting quality when the relationship is already functioning poorly, whereas improvements above a critical threshold may enable substantially greater cooperation. Similarly, psychological distress may exert disproportionately stronger effects after reaching levels that interfere with emotion regulation and daily functioning. Parenting self-efficacy may show diminishing returns once parents achieve sufficient confidence to manage routine parenting tasks. These possibilities are difficult to capture adequately using exclusively linear statistical models.

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Conventional multiple regression is valuable for estimating average linear effects, but it generally requires explicit specification of nonlinear terms and interactions. Machine-learning approaches can identify more complex predictive structures without requiring all functional forms to be predetermined.

Gradient Boosting Regression is particularly suitable for this purpose because it constructs an ensemble of sequential decision trees, with each new tree attempting to reduce the residual error of the preceding ensemble. This procedure allows the model to represent nonlinear associations and conditional relationships while retaining strong predictive accuracy in structured tabular data. The method is also compatible with feature-importance procedures that permit researchers to assess the relative contribution of predictors. In family psychology, this is useful because relational and psychological variables rarely operate independently or with perfectly linear effects. For example, psychological distress may be more detrimental when marital adjustment is already low, whereas strong marital functioning may partially buffer the relational consequences of distress. Similarly, high parenting self-efficacy may be most beneficial within relationships that provide adequate partner support. Although traditional family research has generated substantial evidence concerning associations among these variables, fewer studies have explicitly approached co-parenting as a prediction problem using nonlinear supervised learning.

Existing evidence also demonstrates the importance of considering stress occurring outside the immediate parenting relationship. Psychological distress arising from organizational and occupational conditions can affect work performance and general psychological functioning (Parent-Lamarche et al., 2022), while work-family conflict can transmit pressures between occupational and family systems (Dias et al., 2026). Such findings imply that psychological distress may summarize influences originating from multiple life domains. At the same time, positive family relationships may provide an important source of resilience when parents encounter these pressures. The coexistence of risk and protective factors suggests that prediction models should include relational quality, personal competence, and emotional strain simultaneously rather than examining them in separate models.

Family processes also vary according to the nature of caregiving demands and the extent to which parents perceive their partners as responsive and supportive. Studies of families managing developmental disabilities, serious illness, bereavement, or other challenges consistently indicate that individual adaptation is embedded in relational contexts. For example, parental distress has been associated with functional difficulties in children and with marital functioning (Özoğuz et al., 2025); partner responsiveness has been implicated in parenting concerns among parents with cancer (Ding et al., 2026); and perceived competence has been associated with adjustment following spousal loss (Williams, 2023). These different research contexts converge on a common proposition: parents' capacity to function cooperatively depends on both the quality of the couple relationship and the psychological resources available to individual parents.

The Brazilian sociocultural context provides an important setting in which to investigate these relationships. Changes in employment patterns, gender-role expectations, parental involvement, and the distribution of caregiving tasks have increased the need for parents to negotiate responsibilities collaboratively. Co-parenting quality is therefore likely to depend not only on agreement regarding child-rearing but also on whether partners maintain an adequately adjusted marital relationship, feel competent in their parenting roles, and possess sufficient psychological resources to regulate stress. A predictive model integrating these domains may therefore have practical value for identifying families at greater risk of co-parenting difficulties and for determining which modifiable characteristics warrant priority in preventive intervention.

Despite substantial evidence linking marital functioning, parental competence, and psychological distress with different dimensions of family adaptation, several gaps remain. Much of the existing literature has examined these constructs through correlational, mediation, or traditional regression approaches. Research directly predicting co-parenting quality from marital adjustment, parenting self-efficacy, and psychological distress within a unified machine-learning framework remains limited. Furthermore, linear models may underestimate threshold effects or nonlinear combinations among these predictors. Gradient Boosting Regression offers an opportunity to evaluate predictive performance while simultaneously estimating the comparative importance of relational and psychological variables. Such an approach complements explanatory family research by focusing on how accurately individual families' co-parenting quality can be estimated from observable psychological characteristics.

Accordingly, the present study aimed to predict co-parenting quality from marital adjustment, parenting self-

efficacy, and psychological distress among Brazilian parents using Gradient Boosting Regression and to determine the relative predictive importance and nonlinear contribution of these variables.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional predictive design using supervised machine learning to estimate co-parenting quality from marital adjustment, parenting self-efficacy, and psychological distress. The target population consisted of Brazilian parents who were married or cohabiting with the other biological or adoptive parent of at least one child. Participants were recruited from community settings, family health services, schools, parenting networks, and online parent groups in several Brazilian states, with the largest proportions residing in São Paulo, Minas Gerais, Rio de Janeiro, Paraná, and Rio Grande do Sul. Eligibility criteria were being at least 18 years old, currently living with a spouse or partner with whom parenting responsibilities were shared, having at least one child between 3 and 12 years of age living in the household, being able to read Portuguese, and providing informed consent. Parents were excluded when they reported that the couple relationship had ended, the co-parent did not have an active caregiving role, or more than 20% of questionnaire responses were missing. A total of 493 individuals accessed the survey and provided preliminary consent. Twenty-one records were excluded because eligibility requirements were not met or questionnaires were substantially incomplete, and 10 additional records were removed because of duplicate submissions or implausible response patterns. The final analytic sample therefore consisted of 462 parents. Participation was voluntary and anonymous, and respondents completed the questionnaires individually through a secure electronic survey platform. The research procedures followed the ethical principles for research involving human participants, including confidentiality, voluntary participation, the right to withdraw without penalty, and use of data exclusively for scientific purposes.

2.2. Measures

Co-parenting quality was assessed using the Coparenting Relationship Scale developed by Feinberg and colleagues. The scale contains 35 items assessing central dimensions of the co-parenting relationship, including co-parenting agreement, co-parenting closeness, endorsement of the partner's parenting, division of labor, exposure of the child to interparental conflict, co-parenting support, and co-parenting undermining. Items are rated on Likert-type response formats reflecting the frequency or degree to which each statement characterizes the respondent's relationship with the co-parent. Negatively formulated items are reverse scored where required so that higher overall scores indicate a more positive, supportive, and coordinated co-parenting relationship. For the present study, a total co-parenting quality score was calculated by summing the appropriately coded items, with possible scores ranging from 0 to 210. The Brazilian Portuguese version was administered using standardized translation and adaptation procedures. Previous research using the instrument has supported its multidimensional construct validity, internal consistency, and associations with couple functioning, parenting behavior, and family adjustment. In the present sample, the total score demonstrated excellent internal consistency, with Cronbach's alpha of .93 and McDonald's omega of .94.

Marital adjustment was measured using the Revised Dyadic Adjustment Scale. This 14-item measure evaluates the overall quality of couple adjustment through three interrelated dimensions: dyadic consensus, dyadic satisfaction, and dyadic cohesion. Items assess the extent of agreement between partners on important areas of family and relationship life, satisfaction and stability within the relationship, and engagement in shared activities and emotionally meaningful exchanges. Response options vary according to item content, and item scores are summed to form a total score ranging from 0 to 69, with higher scores representing better marital adjustment. The scale is widely used in both community and clinical research because it provides a concise assessment of relationship functioning while retaining the principal dimensions represented in the original Dyadic Adjustment Scale. The Portuguese-language version was used in the present research. Previous studies have supported its factorial validity, convergent validity, discrimination between distressed and nondistressed couples, and satisfactory internal consistency. Cronbach's alpha for the total marital adjustment score in the present study was .90, while McDonald's omega was .91.

Parenting self-efficacy was measured using the efficacy component of the Parenting Sense of Competence Scale. The instrument assesses parents' perceived competence and confidence in performing the parenting role and managing ordinary child-rearing demands. The efficacy items evaluate the degree to which parents believe that they possess

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sufficient skills, knowledge, and problem-solving capacity to respond effectively to their children's needs and behavioral challenges. Items were rated on a six-point Likert scale ranging from strong disagreement to strong agreement, after which negatively worded items were reverse coded when necessary. Seven efficacy items were summed to obtain the parenting self-efficacy score, resulting in a possible range from 7 to 42, with higher scores indicating greater perceived parenting efficacy. The scale has been extensively used in parenting research and has demonstrated satisfactory construct validity, internal consistency, and meaningful relationships with parenting stress, psychological adjustment, and adaptive parenting practices. The Brazilian Portuguese wording was used in the present study. Internal consistency for the parenting self-efficacy score was satisfactory, with Cronbach's alpha of .86 and McDonald's omega of .87.

Psychological distress was assessed using the 10-item Kessler Psychological Distress Scale. The K10 measures nonspecific psychological distress by assessing symptoms of nervousness, hopelessness, restlessness, depressed mood, fatigue, and feelings that ordinary activities require excessive effort. Participants indicated how frequently they had experienced each symptom during the preceding four weeks on a five-point response scale ranging from 1, indicating none of the time, to 5, indicating all of the time. Item scores were summed to produce a total score ranging from 10 to 50, with higher scores reflecting greater psychological distress. The K10 is widely used in epidemiological, clinical, and community research because it efficiently captures general emotional distress without requiring a disorder-specific diagnostic interpretation. Previous validation research has demonstrated strong internal consistency, convergent validity with measures of depression and anxiety, and good ability to differentiate individuals with lower and higher levels of mental health problems. The validated Brazilian Portuguese version was administered. In the present sample, internal consistency was excellent, with Cronbach's alpha of .92 and McDonald's omega of .92.

2.3. Data Analysis

Data analysis was conducted using Python-based statistical and machine-learning procedures. Preliminary analyses included assessment of missing values, response ranges, distributional properties, descriptive statistics, and bivariate Pearson correlations. Missing data accounted for less than 1.5% of item-level responses, and missing values remaining after scale scoring were imputed using the median calculated within the training data to prevent information leakage. Because tree-based Gradient Boosting Regression does not require predictors to follow a normal distribution or to be standardized, raw scale scores were retained for model estimation. Nevertheless, skewness and kurtosis were examined to identify severe distributional abnormalities, and no variable showed problematic univariate distributional characteristics. The data set was randomly divided into an 80% training set and a 20% holdout test set using a fixed random seed to ensure reproducibility. This produced 369 observations for model development and 93 observations for final out-of-sample evaluation.

Gradient Boosting Regression was fitted with co-parenting quality as the continuous outcome and marital adjustment, parenting self-efficacy, and psychological distress as predictors. Hyperparameter tuning was performed exclusively within the training set using five-fold cross-validation. Candidate values were evaluated for number of estimators, learning rate, maximum tree depth, minimum number of observations per terminal node, and subsampling fraction. Model selection was based primarily on cross-validated root mean squared error while also considering the coefficient of determination. The final model used 300 boosting estimators, a learning rate of .03, maximum tree depth of 2, minimum leaf size of 8, and subsample proportion of .80. Model performance was subsequently assessed on the untouched test sample using R^2, root mean squared error, mean absolute error, and mean absolute percentage error. A standard multiple linear regression model using the same three predictors was estimated as a transparent baseline so that the incremental predictive value of Gradient Boosting Regression could be evaluated. Predictor contributions in the final boosting model were examined using permutation importance and mean absolute SHAP values. Partial dependence patterns were inspected to determine whether predictor-outcome relationships were approximately linear or contained thresholds, plateaus, or other nonlinearities. All reported predictive estimates for the final model were based on the holdout test set rather than training performance.

3. Findings and Results

The final sample consisted of 462 Brazilian parents. Of these participants, 257 were women (55.6%) and 205 were men (44.4%). Participants ranged in age from 23 to 56 years,

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with a mean age of 37.84 years (SD = 6.91). Regarding relationship status, 338 participants (73.2%) were legally married and 124 (26.8%) were living in a stable cohabiting union. The mean relationship duration was 11.26 years (SD = 6.18). Most participants had one or two children: 174 respondents (37.7%) reported one child, 205 (44.4%) reported two children, and 83 (18.0%) reported three or more children. Regarding educational attainment, 91 participants (19.7%) had completed secondary education or less, 221 (47.8%) held an undergraduate qualification or were currently enrolled in higher education, and 150 (32.5%) had completed postgraduate education. A total of 351 respondents (76.0%) were employed either full-time or part-time, whereas 111 (24.0%) were not in paid employment at the time of data collection.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variable	M	SD	Min	Max	Skewness	Kurtosis	1	2	3	4
1. Co-parenting quality	146.72	25.68	74	199	-0.31	-0.42	1.00			
2. Marital adjustment	46.82	8.74	19	65	-0.38	-0.15	.66***	1.00		
3. Parenting self-efficacy	29.56	5.41	14	41	-0.22	-0.34	.52***	.37***	1.00	
4. Psychological distress	20.93	7.22	10	45	0.59	-0.18	-.58***	-.46***	-.41***	1.00

As shown in Table 1, participants generally reported moderately high co-parenting quality and marital adjustment, while considerable individual variation was evident across all four measures. Co-parenting quality was strongly and positively correlated with marital adjustment, $r = .66$, $p < .001$, indicating that parents who reported more satisfactory and coordinated couple relationships also tended to report more supportive co-parenting. Parenting self-efficacy demonstrated a moderate positive correlation with co-parenting quality, $r = .52$, $p < .001$, whereas psychological distress demonstrated a moderately strong negative correlation with co-parenting quality, $r = -.58$, $p < .001$. Marital adjustment was positively related to parenting self-efficacy, $r = .37$, $p < .001$, and negatively associated with psychological distress, $r = -.46$, $p < .001$. Parenting self-efficacy was also negatively correlated with psychological distress, $r = -.41$, $p < .001$. The magnitude of the intercorrelations among predictors did not indicate problematic redundancy, supporting their simultaneous use in the prediction model.

Table 2

Cross-Validation Results and Selected Hyperparameters for Gradient Boosting Regression

Model Specification	Number of Estimators	Learning Rate	Maximum Depth	Minimum Leaf Size	Subsample	Mean CV R^2	Mean CV RMSE	SD of CV RMSE
Candidate model A	100	.05	2	5	1.00	.51	17.71	1.34
Candidate model B	200	.05	2	8	.80	.54	16.95	1.18
Final model	300	.03	2	8	.80	.56	16.57	1.11
Candidate model D	300	.05	3	5	.80	.53	17.09	1.29
Candidate model E	500	.02	3	8	.70	.54	16.88	1.22

Table 2 summarizes the model-tuning stage conducted within the 369-participant training sample. The best cross-validated configuration contained 300 boosting estimators, a learning rate of .03, maximum tree depth of 2, minimum terminal leaf size of 8, and a subsampling fraction of .80. This model produced a mean cross-validated R^2 of .56 and

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an RMSE of 16.57, with relatively limited variability in prediction error across folds. Increasing tree complexity to a maximum depth of 3 did not improve predictive performance and produced slightly higher cross-validation error, suggesting that deeper trees increased model variance without generating sufficient additional predictive information. Similarly, increasing the number of estimators to 500 while reducing the learning rate yielded no meaningful advantage over the selected model. The final configuration was therefore retained because it achieved the lowest mean validation error while maintaining a comparatively parsimonious tree structure.

Table 3

Predictive Performance of Gradient Boosting Regression and the Linear Regression Baseline in the Holdout Sample

Model	R^2	RMSE	MAE	MAPE
Multiple linear regression	.49	18.23	14.52	10.41%
Gradient Boosting Regression	.61	15.95	12.41	8.73%

The final Gradient Boosting Regression model demonstrated satisfactory out-of-sample predictive performance, explaining 61% of the variance in co-parenting quality in the holdout sample. The test RMSE was 15.95 points, while the mean absolute prediction error was 12.41 points and the mean absolute percentage error was 8.73%. The model therefore predicted individual co-parenting scores with substantially less error than the multiple linear regression baseline. The linear model explained 49% of test-set variance, with an RMSE of 18.23 and MAE of 14.52. Relative to the linear model, Gradient Boosting increased explained variance by 12 percentage points and reduced RMSE by approximately 12.5%. The difference indicates that the associations of marital adjustment, parenting self-efficacy, and psychological distress with co-parenting quality were not entirely captured by a purely additive linear specification and that modeling nonlinearities and conditional partitions produced meaningful improvement in prediction.

Table 4

Predictor Importance in the Final Gradient Boosting Regression Model

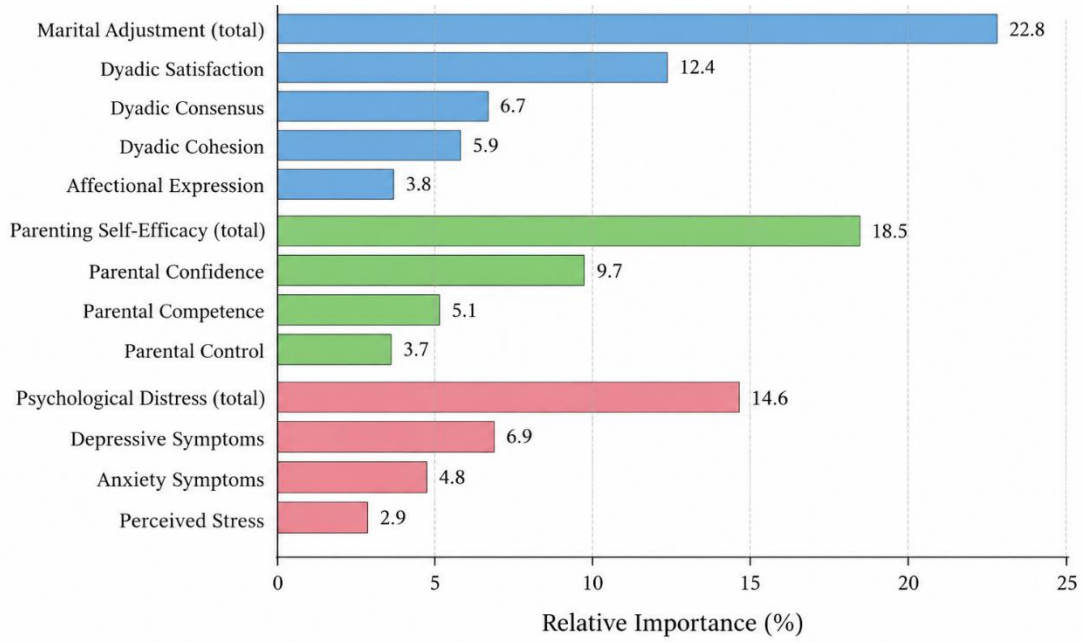
Predictor	Normalized Feature Importance	Permutation Importance in R^2	Mean Absolute SHAP Value	Overall Direction
Marital adjustment	.48	.264	12.84	Positive
Psychological distress	.31	.171	8.19	Negative
Parenting self-efficacy	.21	.108	5.73	Positive

Table 4 indicates that marital adjustment was the most influential predictor of co-parenting quality across all importance metrics. It accounted for 48% of normalized tree-based importance and produced the largest deterioration in predictive performance when its observed values were randomly permuted. Its mean absolute SHAP value of 12.84 also showed that variation in marital adjustment generated the largest average changes in individual predicted co-parenting scores. Psychological distress was the second most influential predictor, with normalized importance of .31 and a predominantly negative relationship with predicted co-parenting quality. Parenting self-efficacy contributed the remaining .21 of normalized importance and demonstrated a positive relationship with predicted co-parenting. The results therefore indicate that all three variables provided nonredundant predictive information, although the relational predictor of marital adjustment contributed substantially more to the model than either individual psychological predictor.

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Figure 1

Partial Dependence of Predicted Co-Parenting Quality on Marital Adjustment, Psychological Distress, and Parenting Self-Efficacy



Inspection of the partial-dependence patterns indicated meaningful departures from strict linearity. Predicted co-parenting quality increased gradually across lower levels of marital adjustment but showed a steeper positive gradient once marital adjustment scores exceeded approximately 44 to 46 points, after which the rate of improvement became somewhat less pronounced above approximately 58 points. Psychological distress showed an inverse pattern: predicted co-parenting remained comparatively stable at low distress levels but declined more sharply when K10 scores exceeded approximately 22 to 24 points, with the most unfavorable predicted values observed among parents reporting scores above 30. Parenting self-efficacy demonstrated a positive association across most of its range, although the magnitude of additional improvement diminished above scores of approximately 33 to 35. These patterns help explain why Gradient Boosting outperformed the linear baseline and indicate that the predictive influence of the three variables was characterized by threshold and plateau effects rather than perfectly constant slopes.

4. Discussion

The present study examined whether co-parenting quality among Brazilian parents could be predicted from marital adjustment, parenting self-efficacy, and psychological distress using Gradient Boosting Regression. The findings provided substantial support for the proposed predictive framework. All three predictors contributed meaningfully to the model, and the final Gradient Boosting Regression explained 61% of the variance in co-parenting quality in the independent holdout sample. Marital adjustment emerged as the strongest predictor, followed by psychological distress and parenting self-efficacy. Furthermore, Gradient Boosting considerably outperformed a conventional multiple linear regression model, which explained 49% of the variance. Examination of partial-dependence patterns suggested that relationships were not completely linear, because marital adjustment showed a stronger positive influence beyond the midrange, psychological distress became particularly detrimental after reaching moderate levels, and the benefits associated with parenting self-efficacy showed some attenuation at relatively high scores. Taken together, the results indicate that co-parenting quality is predictable from a combination of couple functioning, parental competence beliefs, and psychological well-being and that nonlinear modeling can capture meaningful structure that may be overlooked by exclusively linear approaches.

The finding that marital adjustment was the strongest predictor is theoretically consistent with family systems and spillover perspectives. Co-parenting requires parents to coordinate decisions, regulate disagreements, communicate about children, and validate each other's parenting roles. These processes occur within the same interpersonal relationship that supports marital adjustment. Consequently,

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patterns of communication and conflict developed within the marital subsystem are likely to transfer into parenting-related interactions. Research specifically targeting both marital and co-parenting relationships has demonstrated that these family subsystems are closely connected and can be addressed together within couple intervention (Darwiche et al., 2022). The strong relationship observed in the present study is also consistent with evidence showing that individual and couple psychological factors contribute to marital and relational satisfaction (Chiș et al., 2022). When parents experience greater agreement, cohesion, and satisfaction within their intimate relationship, they may be more capable of interpreting parenting disagreements as manageable differences and preserving a cooperative parental alliance.

The magnitude of the marital-adjustment contribution also aligns with studies of families experiencing elevated caregiving demands. Among mothers of children with autism spectrum disorder, resilience and marital adjustment have been shown to operate as meaningful components of adaptation (Güçlü & Hürmeydan, 2024). Research involving parents of children with autism has similarly connected psychological resources with marital quality (Bayazy & Gur, 2024), while parental distress and marital satisfaction have been linked within family systems affected by children's functional impairments (Özoğuz et al., 2025). These studies support the idea that marital functioning does not operate separately from caregiving. Rather, the couple relationship can act as a platform from which parents distribute responsibilities, provide emotional reassurance, and coordinate responses to family demands. The present findings extend this reasoning by demonstrating that marital adjustment was not simply correlated with co-parenting but constituted the dominant variable in an out-of-sample prediction model.

The partial-dependence pattern for marital adjustment is also noteworthy. The association with predicted co-parenting quality became particularly strong when marital adjustment moved from moderate toward relatively high levels. This pattern suggests that the benefits of marital adjustment may not accumulate at a perfectly constant rate. One interpretation is that a minimum level of trust, cohesion, and problem-solving quality may be necessary before improvements in the couple relationship translate efficiently into co-parenting collaboration. Couples experiencing severe adjustment problems may remain constrained by persistent conflict or disengagement, such that small improvements do not immediately transform their parenting alliance. Once the relationship becomes sufficiently stable, however, additional gains may permit more constructive communication and mutual support. The association between marital conflict, parenting stress, parenting efficacy, and positive parenting observed in fathers is compatible with such a spillover process (Kim, 2026).

Psychological distress emerged as the second most important predictor and was negatively related to co-parenting quality. This result is consistent with research identifying parental psychological distress as an important correlate of parenting difficulties and family functioning. Turgeon and colleagues demonstrated that parenting stress and general distress are associated with co-parenting quality and may produce both actor and partner effects within couples (Turgeon et al., 2023). The present findings provide further evidence that distress is relevant not only to individual mental health but also to the quality of coordination between parents. A distressed parent may have greater difficulty regulating irritability, considering the partner's perspective, tolerating disagreement, or remaining emotionally available during parenting-related discussions. Because co-parenting involves frequent negotiation of routines, discipline, schooling, schedules, and child needs, even moderate reductions in emotional regulation may accumulate into broader patterns of reduced support and increased undermining.

The observed threshold-like association between psychological distress and co-parenting is especially important. Prediction remained relatively stable at lower distress levels but deteriorated more substantially once distress moved into a moderate range. This pattern is consistent with the possibility that mild symptoms can often be accommodated without major disruption to family collaboration, whereas more substantial distress begins to interfere with cognitive flexibility, patience, communication, and interpersonal sensitivity. Evidence from the COVID-19 period showed substantial elevations in parental stress, anxiety, and depression under environmental strain (Johnson et al., 2021), while other research demonstrated that social support can moderate distress among mothers facing difficult circumstances (Lubis et al., 2024). Such findings indicate that parental distress is responsive to contextual pressures and available resources. The present results suggest that preventing distress from progressing beyond moderate levels may be particularly relevant for preserving co-parenting quality.

The relevance of distress is also consistent with studies conducted during demanding family transitions. Paternal

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postpartum depression has been associated with psychosocial factors within the family context (Shariat et al., 2022), while couple-level postpartum research has implicated both anxiety and depressive symptoms in parental adaptation (Latulippe et al., 2026). Similarly, work-family conflict has been associated with parental mental health and children's emotional and behavioral difficulties (Dias et al., 2026). These findings illustrate how psychological strain originating from childbirth, employment, illness, or caregiving responsibilities can enter family relationships. Co-parenting may be particularly vulnerable because it requires repeated interpersonal exchanges at precisely the time when distressed individuals have reduced emotional and attentional capacity. The present model's negative distress contribution is therefore consistent with a broader accumulation-of-stress perspective.

Psychological distress may also alter how parents perceive each other's behavior. Distressed individuals may be more likely to interpret ambiguous partner actions negatively, perceive ordinary disagreements as criticism, or underestimate the partner's supportive intentions. Research on parenting concerns among gynecological cancer patients has emphasized the importance of perceived partner responsiveness (Ding et al., 2026). Similarly, among couples parenting children during advanced cancer, relationship context has been associated with parenting concerns (Milbury et al., 2024). These studies suggest that the interpersonal meaning attributed to partner behavior may be particularly important when parents experience high emotional burden. A parent who feels psychologically overwhelmed may therefore have difficulty perceiving or making effective use of co-parent support even when some support is objectively present.

Parenting self-efficacy was the third predictor but still made a substantial independent contribution to prediction. Higher confidence in one's parenting abilities was associated with better predicted co-parenting quality. This is consistent with the idea that parents who perceive themselves as competent are more likely to approach parenting interactions proactively and less likely to experience differences in parenting opinion as threats to their identity or competence. Evidence among parents of children with autism has identified self-efficacy as an important factor in adaptation alongside coping and social support (Higgins et al., 2022). Self-efficacy has likewise been examined in parents experiencing serious illness, where parenting confidence coexists with distress, parenting concerns, and emotion-regulation demands (Strandh et al., 2024). The present findings extend this literature by showing that parenting confidence contributes directly to prediction of the cooperative relationship between parents.

The positive relationship between parenting self-efficacy and co-parenting may also operate through communication and decision making. Parents who believe they can manage behavioral challenges and developmental demands may communicate their preferences more clearly, participate more confidently in shared decisions, and tolerate reasonable differences in parenting style. In contrast, parents with low efficacy may experience uncertainty that increases dependence on the partner's approval or defensiveness when their parenting is questioned. Research on parental competence and family outcomes provides support for this interpretation. Perceived parental competence has been associated with adjustment among widowed parents (Williams, 2023), and parenting self-efficacy remains psychologically relevant even among older adults who continue to identify strongly with the parental role (Kestler-Peleg et al., 2023). Furthermore, parental competence and psychological distress have been associated with children's psycho-behavioral adaptation (Li et al., 2023), reinforcing the importance of parents' perceived capability within the broader family system.

The plateau observed at higher levels of parenting self-efficacy may indicate that efficacy has its strongest benefits when distinguishing low or moderate confidence from adequate confidence. Once parents possess sufficient confidence to address routine parenting demands, additional increases may contribute relatively little to co-parenting quality unless accompanied by strong couple communication and low psychological distress. This finding illustrates an advantage of using Gradient Boosting Regression because a conventional linear coefficient would imply that every one-unit increase in self-efficacy has an identical expected effect across the entire scale. The current analysis instead suggests diminishing marginal returns at high values. From a family-systems perspective, this makes conceptual sense because excellent individual parenting confidence cannot fully compensate for substantial marital conflict or psychological impairment.

The relative ranking of predictors is also informative. The fact that marital adjustment contributed more strongly than parenting self-efficacy suggests that co-parenting quality may depend more heavily on relational coordination than on either parent's individual confidence alone. Co-parenting is inherently dyadic; therefore, even a highly competent parent

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must negotiate with a partner. This interpretation is supported by findings showing that relationship conditions influence parenting concerns in families managing severe illness (Milbury et al., 2024) and that marital quality is interconnected with broader psychological resources among parents confronting developmental challenges (Bayazy & Gur, 2024). Parenting self-efficacy remains important, but its effect may depend partly on whether the family relationship provides a context in which personal competence can be expressed collaboratively.

The joint influence of the three predictors can also be interpreted through resource-oriented models of family adaptation. The Double ABC-X model emphasizes the interaction of stressors, resources, appraisals, and coping processes in determining family adaptation (Brik & Wang, 2025). Within this framework, marital adjustment can be interpreted as an interpersonal resource, parenting self-efficacy as an intrapersonal mastery resource, and psychological distress as an indicator of accumulated psychological burden. Strong co-parenting is most likely when relational and personal resources are available while psychological burden remains manageable. Similar resource-gain processes have been identified among mothers coping with breast cancer, where psychological resources contributed to more adaptive parenting processes (Zamir et al., 2022). This perspective helps explain why all three variables retained predictive value despite their moderate intercorrelations.

The present results further correspond with resilience-oriented research. Family resilience during periods of major disruption depends on both risk factors and protective resources (Cıhan & Var, 2022). Parents who maintain strong marital adjustment and parenting self-efficacy may be better able to absorb stress without allowing it to disrupt co-parenting coordination. Conversely, when relational resources deteriorate at the same time that distress increases, the family may become more vulnerable to escalating conflict and inconsistent parenting. The effectiveness of psychosocial intervention for reducing distress among caregivers further demonstrates that these processes are potentially modifiable (Masulani-Mwale et al., 2022), supporting the practical value of identifying high-risk predictor profiles.

An additional contribution of the present study concerns the performance of Gradient Boosting relative to multiple linear regression. The increase in test R^2 from .49 to .61 and the corresponding reductions in RMSE and MAE indicate that meaningful predictive information was contained in nonlinear patterns. Importantly, this improvement was evaluated using data that were not used for model estimation or tuning, reducing the likelihood that the result merely reflects overfitting. The findings therefore demonstrate that machine-learning methods can complement traditional explanatory analyses in family psychology. Traditional regression remains valuable for estimating interpretable average associations, whereas Gradient Boosting is advantageous when the primary objective is prediction and relationships are potentially nonlinear.

The predictive approach does not imply that complex family relationships can be reduced to algorithmic scores. Instead, machine learning can be viewed as an additional analytic strategy for identifying combinations of characteristics associated with elevated probability of poor family functioning. Co-parenting develops within a broader social and contextual system, and many relevant variables were not included in the present model. Nevertheless, explaining 61% of out-of-sample variance using only three theoretically meaningful predictors is notable. It suggests that marital adjustment, psychological distress, and parenting self-efficacy together capture a substantial proportion of the interpersonal and psychological processes underlying co-parenting quality.

Overall, the findings reinforce an integrated view of co-parenting in which couple functioning, individual psychological well-being, and parental competence are interconnected. Marital adjustment appears to provide the principal relational foundation for effective co-parenting, psychological distress represents an important risk factor capable of disrupting cooperation, and parenting self-efficacy provides an individual resource that facilitates confident participation in shared parenting. Their effects are not entirely linear, which supports the use of flexible predictive techniques when studying complex family systems.

5. Conclusion

The present study demonstrated that co-parenting quality among Brazilian parents can be predicted with substantial accuracy from marital adjustment, parenting self-efficacy, and psychological distress using Gradient Boosting Regression. The model explained 61% of the variance in co-parenting quality in an independent holdout sample and performed meaningfully better than a conventional multiple linear regression model. Marital adjustment was the most influential predictor, indicating the central importance of the

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couple relationship as a foundation for effective parenting coordination, while psychological distress emerged as the second most important predictor and parenting self-efficacy provided an additional positive contribution. The nonlinear patterns identified by the model further suggested that moderate-to-high marital adjustment may generate particularly strong co-parenting benefits, psychological distress may become increasingly disruptive beyond moderate levels, and parenting self-efficacy may display diminishing returns after adequate confidence has been established. These findings support a multidimensional understanding of co-parenting in which relational quality, psychological health, and parenting competence jointly shape parents' capacity to cooperate effectively.

6. Limitations & Suggestions

Several limitations should be considered when interpreting the findings. The cross-sectional design prevents conclusions regarding temporal or causal ordering, meaning that poor co-parenting may itself contribute to marital difficulties or psychological distress rather than functioning solely as an outcome of these variables. All variables were assessed using self-report questionnaires, introducing the possibility of common-method variance, social desirability, and perceptual bias. Although the sample included parents from several Brazilian states, recruitment relied partly on community and online convenience channels and therefore cannot be assumed to represent all Brazilian families, particularly those experiencing severe socioeconomic disadvantage, rural isolation, nontraditional family arrangements, or limited digital access. The analysis also treated participants as individual respondents rather than analyzing both partners from the same family as distinguishable members of a dyad. Consequently, actor and partner contributions could not be separated. Finally, although the model included three theoretically important predictors, co-parenting is influenced by many additional factors, including child temperament, number and age of children, financial stress, social support, gender-role beliefs, division of domestic labor, family-of-origin experiences, and relationship violence, which were not incorporated into the present prediction model.

Future research should evaluate the model longitudinally so that predictors measured at one time point can be used to forecast subsequent changes in co-parenting quality. Recruiting both members of parental couples would permit integration of machine learning with dyadic approaches and allow investigation of whether one parent's distress, marital perceptions, or parenting confidence improves prediction of the partner's co-parenting experience. Future models could incorporate socioeconomic characteristics, work-family conflict, parenting stress, social support, child behavior, parental emotion regulation, and division of household labor to determine whether predictive accuracy increases beyond that achieved by the present three-variable model. External validation using independent samples from different Brazilian regions and other cultural contexts would be particularly important before considering clinical application. Comparison of Gradient Boosting with other algorithms, including random forests, XGBoost, CatBoost, elastic-net regression, support vector regression, and neural-network approaches, could further clarify the best balance between accuracy and interpretability. Longitudinal machine-learning models should also examine whether changes in predictors produce corresponding changes in estimated co-parenting risk.

For practice, the findings suggest that family assessment should not evaluate co-parenting difficulties in isolation. Professionals working with parents may obtain more useful information by simultaneously screening marital adjustment, psychological distress, and confidence in the parenting role. Because marital adjustment contributed most strongly to prediction, persistent couple conflict, poor cohesion, and difficulty reaching agreement may warrant particular attention when parents report co-parenting problems. At the same time, elevated psychological distress should be assessed and addressed because emotional symptoms may interfere with communication and cooperative problem solving even when parents possess adequate parenting knowledge. Parenting interventions may also benefit from strengthening self-efficacy through mastery experiences, behavioral rehearsal, problem-solving training, and constructive feedback. Rather than interpreting low co-parenting quality exclusively as a parenting-skills deficit, practitioners should consider whether the primary difficulty lies in the couple relationship, emotional functioning, perceived parenting competence, or a combination of these domains.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors have equally contributed to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

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